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From the INTERNATIONAL BUREAU

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NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
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in its capacity as elected Office

Date of mailing (day/month/year) 10 April 2000 (10.04.00)	
International application No. PCT/GB99/03179	**Applicant's or agent's file reference** R037526PPC
International filing date (day/month/year) 22 September 1999 (22.09.99)	**Priority date** (day/month/year) 22 September 1998 (22.09.98)
Applicant LEWIS, Meirion et al	

1. The designated Office is hereby notified of its election made:

   [X] in the demand filed with the International Preliminary Examining Authority on:

   09 March 2000 (09.03.00)

   [ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was [ ] was not

   made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland** Facsimile No.: (41-22) 740.14.35	Authorized officer Juan Cruz Telephone No.: (41-22) 338.83.38

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference RO37526PPC	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/GB99/03179	International filing date *(day/month/year)* 22/09/1999	Priority date *(day/month/year)* 22/09/1998
International Patent Classification (IPC) or national classification and IPC G01J9/02		
Applicant SECRATARY OF STATE FOR DEFENCE et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 9 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 14 sheets.

3. This report contains indications relating to the following items:

   I ☒ Basis of the report
   II ☐ Priority
   III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   IV ☒ Lack of unity of invention
   V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   VI ☐ Certain documents cited
   VII ☐ Certain defects in the international application
   VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
09/03/2000	27.12.2000
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Schmidt, C. Telephone No. +49 89 2399 2254

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB99/03179

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).)*:

Description, pages:

5-39	as originally filed			
1-4,4a	as received on	16/10/2000	with letter of	13/10/2000

Claims, No.:

1-42	as received on	16/10/2000	with letter of	13/10/2000

Drawings, sheets:

1/8-8/8	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees the applicant has:

   - ☐ restricted the claims.
   - ☐ paid additional fees.
   - ☐ paid additional fees under protest.
   - ☐ neither restricted nor paid additional fees.

2. ☒ This Authority found that the requirement of unity of invention is not complied and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is

   - ☐ complied with.
   - ☒ not complied with for the following reasons:
     see separate sheet

4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:

   - ☒ all parts.
   - ☐ the parts relating to claims Nos. .

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	3-5,9,13-16,18-23,26-42
	No:	Claims	1,2,6,7,8,10-12,17,24,25

Inventive step (IS)	Yes:	Claims	
	No:	Claims	1 - 42
Industrial applicability (IA)	Yes:	Claims	1-42
	No:	Claims	

2. Citations and explanations
   see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

CITED DOCUMENTS

D1: US-A-5 396 166 (VOHRA SANDEEP T ET AL) 7 March 1995 (1995-03-07)

D2: US-A-4 972 424 (WISSMAN CHARLES H) 20 November 1990 (1990-11-20)

D3: DE 42 24 744 A (ABB Research Ltd.) 3 February 1994 (1994-02-03)

D4: US-A-5 204 640 (CALIFORNIA INST. OF TECHN.) 20 April 1993

D5: EP-A-0552 415 (GENERAL INSTR. CORP) 28 July 1993

D6: GB-A-2 307 332 (Secr. of State for Defence) 21 May 1997

SECTION IV

The separate inventions/groups of inventions are:

Claims 1 - 26 and 39: concern an optical phase detector characterised in that a voltage-controlled electro-optic phase modulator is used to modulate the phase of one optical input, wherein the difference is fed back to the controlled modulator, the applied voltage providing an indication of the phase difference between the two optical inputs.

Claims 27 - 38 and 40: concern a laser stabilisation apparatus and a method for stabilising the output from a laser wherein a relative delay is introduced between the two primary optical outputs and the difference signal is fed back to the laser.

These two groups of claims are not so linked as to form a single general inventive concept (Rule 13.1 PCT) for the following reasons:

No common specific technical features (ie features forming a contribution over the prior art) can be seen which could be said to incorporate a common inventive concept. In the first group of claims the phase is measured by controlling the voltage-controlled modulator to be at zero voltage. This technique has no common feature with the stabilisation feedback which can be used also without such a voltage-controlled modulator (cf p. 23, second paragraph). Thus, these claims are directed at different apparatuses solving different problems without a common concept.

SECTION V

First group - claims 1- 26 and 39 - 41

1. The invention according to claim 1 concern an optical phase detector wherein two optical inputs are combined, the intensity of the combined beams are detected and the difference is used for a feedback control of a phase modulator to determine the phase difference.

2. Document D3, which is considered as the closest prior art, discloses an apparatus for detecting loose metal parts in a high voltage system. The discloses system uses a fibre optic Mach Zender Interferometer with feedback control which can be considered as an optical phase detector comprising (cf. figure 1):
   -means (Strahlteiler 6) for receiving two optical inputs (1, 2) and producing two combined optical outputs (the two branches after combiner 6);
   -detection means (7) for detecting the intensity of the two combined outputs and providing respective electrical signals;
   -means for measuring the difference between the two electrical signals and generating an output difference signal (Regelkreis 8; cf. column 3, lines 25 to 40); and
   -an electro-optic phase modulator (9) for modulating the phase of one optical input (2).

   Thus, D3 discloses an optical phase detector having all the features of present claim 1.

3. Dependent claims 2 to 26 and 39 to 41 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty and/or inventive step, the reasons being as follows:

   Claims 2 and 3: D3 specifies the frequency to 10Hz to 10MHz (claim 5); the

definition of 1 GHz in claim 3 does not contain any technical features enabling this and thus the pure wish cannot be considered inventive over D3 - the skilled person would obviously look for possibilities OT provide higher frequencies if needed.

Claims 4, 6, 7, 10, 11 and 12: D3 discloses one kind of coupling means (ie the beam splitter 6), other kinds of such means are generally known (cf. eg D1: coupler 28). Claim 6 does not add any new features compared to claim 1. Also in D3 is the voltage kept at zero level (c. 3, l.33) and the phase modulator is an optical fibre carrying a piezoelectric material. D3 supplies inputs of equal amplitudes from a single source.

Claims 8 and 9: the use of other modulators is an obvious matter of choice for the skilled person; the materials are well known in the art.

Claim 13: the use of two sources is obvious to the skilled person.

Claim 14: fibre couplers are generally known (cf. D1) and their incorporation is considered as a minor design matter.

Claims 15 and 16: the use of a polarizer is a standard measure in the art.

Claims 17 and 18: Also D3 uses two photodetectors, that they should be matched is trivial.

Claim 19 - 23: the use of a delay line in an optical frequency discriminator is considered as a standard measure (cf. also D4 and D6: delay lines 322 and 24 respectively).

Claims 24 to 26: also in D3 is the phase detector used in a sensor; the use in other kinds of sensors is considered obvious.

Claim 39: the use as a voltmeter is considered obvious since it does not change the basic configuration and in D3 it is clearly stated that the phase detector used is a standard Mach Zender arrangement.

Claim 40: the use of such a standard Mach Zender arrangement also in a frequency synthesizer is considered obvious in view of D6 showing a similar arrangement.

4. Industrial applicability is given in the field of phase detection/stabilisation.

Second group - claims 27 - 38 and 42

1. The invention according to claims 27 and 42 concerns a laser stabilisation apparatus comprising means for producing two outputs of a primary input from the laser and means for introducing a relative delay between the two outputs as well as detecting the phase difference between these outputs, and further a feedback means is provided to feed back the difference signal to stabilise the laser source.

2. The present application does not satisfy the criterion set forth in Article 33 (3) PCT because the subject-matter of claims 27 and 42 does not involve an inventive step. The use of feedback to stabilise a laser based on phase detection is well known in the art: reference is made in this aspect to documents D4 to D6 all showing examples of such arrangements. The provision of a specific, known (as discussed above with regard to D3), phase detector in such a feedback arrangement can therefore not be considered inventive.

3. Dependent claims 28 to 38 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty and/or inventive step, the reasons being as follows:

   Claims 28 and 29: the use of a plurality of stabilisation apparatuses and different control points is a mere design feature.

   Claims 30 to 32: these features are already disclosed in D3 as discussed above.

   Claims 33 to 38: means for varying the laser frequency are considered trivial in the art of laser stabilisation. The features of a differential amplifier, fibres with

different path lengths and a phase modulator have already been discussed above. The use of a Sawtooth-like voltage waveform is considered as a minor design feature.

4. Industrial applicability is given in the field of laser stabilisation.

SECTION VIII

1. Claim 24 should be dependent on claim 6 (which corresponds to claim 4 as originally filed).

2. Claim 6 is redundant since it only defines feature already included in claim 1 upon which it depends.

OPTICAL PHASE DETECTOR

The invention relates to an optical phase detector for measuring the phase difference between two input signals. The invention also relates to applications of an optical phase detector, including use in an optical frequency discriminator and a laser stabilisation apparatus.

Conventionally, phase difference may be measured optically by interfering two beams to form an interference fringe pattern and measuring the fringe pattern as it moves across a camera face due to a change in the relative phase. A disadvantage of this type of measurement is that it relies on the counting of fringes and interpolation between fringes to measure phase or position accurately. This process can be relatively slow and not especially accurate. Such detectors may be used in displacement measurement schemes, such as in laser metrology, to measure position accurately i.e. to a fraction of an optical wavelength.

Optical techniques have previously been used for the generation of microwave radiation, by mixing two stable lasers, and for phased array antenna beam-forming, in which simple optical systems are used to perform a complicated microwave function. A known technique for the generation of stabilised microwave radiation has been achieved by incorporating a fibre optic delay line in an RF, microwave or millimetre wave (mm-wave) frequency discriminator circuit. This enables the difference in frequency of two stable laser inputs to be controlled accurately and therefore the RF, microwave or mm-wave output can be stabilised (UK patent application 9523518.0). In this system the frequencies of the lasers can drift but the difference in frequency between them remains

constant. It is an object of the system to provide an apparatus for providing stable radiation at RF frequencies.

In many applications high spectral purity (i.e. stable) laser radiation is required. These applications include fundamental physics research, for example graviton detection, photochemistry, luminescence excitation spectroscopy, absorption and Raman spectroscopy, and applications such as fibre optic communications, sensors, laser radar, laser air speed indicators and laser vibrometry. However, lasers of well defined frequency (or wavelength) and high spectral purity (e.g. narrow linewidth) tend to be expensive and complex. High spectral purity is attainable with certain gas lasers, but there is a need for solid state lasers of similar or superior performance. Solid state lasers include laser diodes and diode pumped YAG lasers. The most widely used laser device is the laser diode. Although these devices are relatively cheap, devices of this kind have a particularly poor spectral stability, especially in the case of Fabry-Perot etalon designs which often support several modes simultaneously.

For many applications, it is useful to overcome the problem of poor spectral quality and to be able to stabilise the frequency output of a single laser. Furthermore, for some applications, extremely pure laser radiation is required.

The stabilisation of a laser output with an external component has previously been reported [*FM noise reduction and sub kilohertz linewidth of an AlGaAs laser by negative electrical feedback, M. Ohutso et al., IEEE Journal of Quantum Electronics 26 (1990) pp231-241*]. In this system, the external component is one or more high finesse Fabry-Perot (FP) interferometer. Stabilisation of the laser is achieved by utilising the reflectance characteristics of the interferometer or interferometers to detect FM noise. Electrical feedback

is then used to feed back this signal to correct the laser output. However, the system is a complex, free-space system which gives cost disadvantages. Also, because the system operates in free space it is particularly susceptible to external factors such as vibration, air circulation and dust and also to changes in temperature.

It is an object of the present invention to provide a laser stabilisation apparatus which overcomes these problems. It is a further object of the invention to provide an optical phase detector which may be included in the laser stabilisation apparatus.

According to a first aspect of the present invention, an optical phase detector comprises;

means for receiving two optical inputs and producing two combined optical outputs,

detection means for detecting the two optical outputs and converting the intensity of each of the combined optical outputs into an electrical signal,

means for measuring the difference between the two electrical signals and generating an output difference signal, and

a voltage-controlled electro-optic phase modulator for modulating the phase of one optical input to the optical phase detector, the electro-optic phase modulator having a substantially linear response whereby, in use, the output difference signal is maintained at a substantially constant level by varying the

voltage applied to the electro-optic phase modulator, the applied voltage providing an indication of the phase difference between the two optical inputs.

The optical phase detector may include coupling means for receiving two optical inputs and producing two combined optical outputs. The coupling means may be any means for producing two combined optical outputs from the two optical inputs, wherein the coupling means produce two intermediate optical outputs from each of the optical inputs, the two intermediate optical outputs produced from each of the optical inputs being in phase quadrature, and wherein the intermediate optical outputs are combined to form the two combined optical outputs. For example, the coupler may be an optical fibre coupler, or other coupled waveguide device, such as in integrated optic waveguide coupler.

Preferably, the constant level is substantially zero volts. As the voltage applied to the electro-optic phase modulator provides an indication of the phase difference between the two optical inputs, this provides the advantage that the optical phase detector is linearised as the voltage required to drive the electro-optic phase modulator is directly proportional to the phase difference between the two optical inputs. It may be preferable to apply this voltage to the electro-optic modulator by means of a feedback loop from the optical phase detector output. The optical phase detector may therefore further comprise means for feeding back the output difference signal to the electro-optic phase modulator, the applied voltage to the electro-optic modulator being varied in response to the output difference signal so as to maintain the difference signal at the substantially constant level.

CLAIMS

1. An optical phase detector (30) comprising;

means (2) for receiving two optical inputs (3,4) and producing two combined optical outputs (11,12),

detection means (32) for detecting the intensity of the two combined optical outputs and converting the intensity of each of the combined optical outputs (11,12) into an electrical signal, and

means (6) for measuring the difference between the two electrical signals and generating an output difference signal (20),

characterised in that the optical phase detector further comprises a voltage-controlled electro-optic phase modulator (35) for modulating the phase of one optical input to the optical phase detector, the electro-optic phase modulator having a substantially linear response whereby, in use, the output difference signal (20) is maintained at a substantially constant level by varying the voltage (36) applied to the electro-optic phase modulator (35), the applied voltage providing an indication of the phase difference between the two optical inputs (3,4).

2. The optical phase detector of claim 1, including coupling means (2) for receiving the two optical inputs (3,4) and producing the two combined optical outputs (11,12).

3. The optical phase detector of claim 2, wherein the coupling means (2)

produce two intermediate optical outputs from each of the optical inputs (3,4), the two intermediate optical outputs produced from each of the optical inputs being in phase quadrature, and

wherein the intermediate optical outputs are combined to form the two optical outputs (11,12).

4. The optical phase detector of any of claims 1-3, and further comprising means (44, 46) for feeding back the output difference signal to the electro-optic phase modulator (35), the applied voltage to the electro-optic modulator being varied in response to the output difference signal so as to maintain the difference signal at the substantially constant level.

5. The optical phase detector of claim 4, wherein the substantially constant level is zero volts.

6. The optical phase detector of any of claims 1-5, wherein the electro-optic phase modulator (35) comprises an optical waveguide on an integrated optic substrate.

7. The optical phase detector of claim 6 wherein the substrate is any of lithium niobate, lithium tantalate or gallium arsenide.

8. The optical phase detector of any of claims 1-5, wherein the electro-optic phase modulator (35) takes the form of an optical fibre carrying a piezoelectric material.

9. The optical phase detector of any of claims 1-8 wherein the frequency response of the electro-optic phase modulator (35) is at least 1 MHz.

10. The optical phase detector of claim 9 wherein the frequency response of the electro-optic phase modulator (35) is at least 1 GHz.

11. The optical phase detector of any of claims 1-10, wherein the optical inputs (3,4) have substantially equal amplitudes.

12. The optical phase detector of any of claims 1-11 wherein the optical inputs (3,4) are obtained from the same source of radiation.

13. The optical phase detector of any of claims 1-11 wherein the optical inputs (3,4) are obtained from different sources of radiation.

14. The optical phase detector of any of claims 1-13, comprising an optical fibre coupler (2) for receiving the two optical inputs (3,4).

15. The optical phase detector of any of claims 1-14, and further comprising polarisation modulation means for modulating the polarisation of at least one of the inputs to the optical phase detector so as to ensure the polarisation of the two inputs is substantially the same.

16. The optical phase detector of claim 15, wherein the polarisation modulation means is any one of a fibre-optic polarisation modulator or an integrated optic polarisation modulator.

17. The optical phase detector of any of claims 1-16, comprising two photodetectors (5a,5b), each one for detecting the intensity of one of the two optical outputs (11,12) and for generating an electrical output signal (7a,7b) in response to the corresponding optical output (11,12).

18. The optical phase detector of claim 17 wherein the photodetectors (5a,5b) are matched.

19. A frequency discriminator apparatus (60) comprising the optical phase detector (30) of any of claims 1-18 and further comprising;

input means (41) for receiving a primary optical input (42) from a source of radiation (43) having a frequency, and for producing two primary optical outputs (52, 53),

means (50,51) for introducing a relative delay between the two primary optical outputs (52, 53),

the two primary optical outputs, having a relative delay therebetween, providing the inputs (3,4) to the optical phase detector (1; 30).

20. The frequency discriminator of claim 19, including input coupling means (41) for receiving the primary optical input (42) from the source of radiation (43).

21. The apparatus of claim 19 or 20 wherein the means for introducing a relative delay between the two primary optical outputs comprises two lengths of optical fibre (50,51) having different optical path lengths.

22. The apparatus of claim 19 or 20, wherein the means for introducing a relative delay between the two primary optical outputs comprises one length of optical fibre through which one of the primary optical outputs is transmitted.

23. The apparatus of claim 21 or 22 wherein the one or more length of optical fibre is any one of single mode optical fibre, polarisation maintaining optical fibre, temperature stable single mode optical fibre or temperature stable polarisation maintaining optical fibre.

24. A sensor comprising the apparatus (60) of any of claims 19-23 and including the optical phase detector (30) of claim 4.

25. The sensor of claim 24, wherein the relative optical delay between the two primary optical outputs is substantially zero.

26. The sensor of claim 24 or 25 for measuring any one of a variation in temperature, pressure or strain applied to an optical fibre (50) forming part of the sensor.

27. A laser stabilisation apparatus (70) for stabilising the output (42) from a source of radiation (43) comprising,

a frequency discriminator apparatus (60) comprising input means (41) for receiving a primary optical input (42) from a source of radiation (43) having a frequency and for producing two primary optical outputs (52, 53), means (50,51) for introducing a relative delay between the two primary optical outputs (52, 53) and an optical phase detector (1:30), wherein the optical phase detector

(1; 30) comprises means (2) for receiving the two optical inputs (52, 53) and producing two combined optical outputs (11,12), detection means (32) for detecting the intensity of the two combined optical outputs (11; 12) and converting the intensity of each of the combined optical outputs (11,12) into an electrical signal; and means (6) for measuring the difference between the two electrical signals and generating an output difference signal (20),

the laser stabilisation apparatus further comprising feedback means (72, 74) for feeding back the output difference signal (20) from the optical phase detector (1; 30) of the frequency discriminator (60) to the source of radiation (43).

28. The laser stabilisation apparatus (70) of claim 27 comprising one or more additional frequency discriminator apparatus (60) as in claim 19, each frequency discriminator apparatus having corresponding feedback means (72, 74) for feeding back the electrical output from the associated optical phase detector (1; 30) to the source of radiation (43).

29. The laser stabilisation apparatus (70) of claim 28, wherein the outputs from the optical phase detectors (1:30) of the different frequency discriminators feed back to different control points on the source of radiation (43).

30. The laser stabilisation apparatus (70) of any of claims 27-29, wherein the optical phase detector (30) includes a voltage-controlled electro-optic phase modulator (35; 80) for modulating the phase of one optical input to the optical phase detector (30), the electro-optic phase modulator (35; 80) having a substantially linear response.

31. The laser stabilisation apparatus (70) of any of claims 27-29, including a differential amplifier (82), the output from the optical phase detector (1:30) being fed back to an input of the differential amplifier (82), the output from the differential amplifier (82) being fed back to the source.

32. The laser stabilisation apparatus (70) of any of claims 27-31, wherein the optical phase detector (1; 30) forming part of the laser stabilisation apparatus comprises coupling means (2) for receiving the two optical inputs (3,4) and producing the two combined optical outputs (11,12).

33. An optical frequency synthesizer comprising;

the laser stabilisation apparatus (70) of claim 27 for stabilising an output from a laser, and

means (80;82) for varying the frequency of the laser output.

34. The optical frequency synthesizer of claim 33, including two optical fibres (50,51) for introducing a relative delay between the two primary optical outputs (52, 53), the two optical fibres having different optical path lengths.

35. The optical frequency synthesizer of claim 34, comprising an electro-optic phase modulator (80) arranged in the path of one of the lengths of optical fibres (50,51), whereby application of a SAWTOOTH-like voltage waveform to the electro-optic phase modulator (80; 35) gives rise to a_variation of the frequency of the laser output.

36. The optical frequency synthesizer of claim 35 and further comprising a voltage source, providing a SAWTOOTH-like voltage waveform, for applying a voltage to the electro-optic phase modulator (80; 35).

37. The optical frequency synthesizer of claim 33, comprising a differential amplifier (82), the output from the optical phase detector (1:30) being fed back to an input of the differential amplifier (82), the output from the differential amplifier being fed back to the laser.

38. The optical frequency synthesizer of claims 33, wherein the optical phase detector (30) includes an electro-optic phase modulator (35; 80).

39. An optical vector voltmeter (90), for comparing an input laser signal (92) and a reference signal (94) comprising;

the optical phase detector (30) of claim 4 or 5, and

a photodetector (96) for receiving the input laser signal (92) and for generating an output signal dependent on the amplitude of the input laser signal (92),

the output from the electro-optic phase modulator (35) providing a measure of the phase difference between the reference signal (94) and the input laser signal (92).

40. An optical network analyser for measuring the transmitted or reflected amplitude and phase of a system (110) at a plurality of frequencies comprising;

an optical frequency synthesizer for generating a reference signal (76) at a plurality of frequencies, and

the optical vector voltmeter (90) of claim 39, for receiving as inputs the reference signal (76) and the signal transmitted or reflected by the system (110).

41. The optical network analyser of claim 40, wherein the optical frequency synthesizer is as claimed in any of claims 33-38.

42. A method of stabilising the output (42) from a source of radiation (43) comprising the steps of;

providing a frequency discriminator apparatus (60) comprising input means (41),

inputting a primary optical input (42) from a source of radiation having a frequency to the input coupling means (41) and producing two primary optical outputs (52, 53),

introducing a relative delay between the two primary optical outputs (52, 53),

inputting the two primary optical outputs to an optical phase detector (1; 30), comprising coupling means (2) for receiving the two optical inputs (3,4) and producing two combined optical outputs (11,12),

detecting the intensity of the two combined optical outputs (11,12);

converting the intensity of each of the combined optical outputs (11,12) into an electrical signal,

measuring the difference between the two electrical signals and generating an output difference signal (20), and

feeding back the output difference signal (20) from the optical phase detector (1) of the frequency discriminator (60) to the source of radiation (43).